

Cortical Control of Neural Prostheses

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By

Andrew Schwartz, Ph.D., Principal Investigator
Gary Yamaguchi, Ph.D., Co-Principal Investigator
Daryl Kipke, Ph.D.
Jiping He, Ph.D.
Jennie Si, Ph.D.
James Sweeney, Ph.D.
Stephen Helms Tillery, Ph.D.

The Whitaker Center for Neuromechanical Control
Bioengineering Program
Arizona State University
Tempe, Arizona 85287-6006

Work Performed During the Reporting Period

In this reporting period, we continued to record spike data from our previously implanted monkeys H and K. These animals were implanted with micro-wire arrays consisting of Teflon-coated stainless steel wires (50 microns in diameter) arranged in two linear arrays of eight wires each (spaced two hundred microns apart). The stainless steel electrode arrays were purchased from NB Labs. Monkey H was also previously implanted with a new prototype electrode that has a self-contained microdrive.

The NB electrodes that were implanted in the left hemisphere of animal H on 9/9/98 are still producing data. Currently there are 6 active neurons recorded on those implants. At this point, we have recorded activity from that array for over a year.

The microwire arrays in animal K are still producing data, and in fact one of the 4 arrays recently became active after a quiescent interval. Presently, we are recording 39 neurons from those arrays.

Daily recording sessions for animals H and K, and training sessions for animals L and M on the 3d center->out task are continuing.

As described at the end of our previous contract, we have developed 3 computational methods to extract movement direction from the activity of an ensemble of motor cortical neurons. We have also now developed a new real-time program that will allow us to employ any of these algorithms to directly control the robotic arm from motor control signals. This program samples motor cortical activity at 20 msec intervals, computes a direction of movement based on the activity of that ensemble, and outputs the control signal to a robot controller 20 msec later. Modules to compute movement direction based on a population vector algorithm and a principal component based analysis have been implemented and are presently being

tested. The fuzzy control algorithm discussed at the end of our previous contract is still under development. Once we are confident that we can produce reliable directional signals from that algorithm, we will build a module to use in the real-time program.

We are still controlling the robot on-line, but out of sight of the animal as we finish debugging the software that extracts neuronal signals and computes velocity commands.

We have also begun developing a setup to do experiments using virtual reality technology. The mechanical framework to support both the animals and the computer hardware has been constructed and installed in the recording room. At this time we are going through software that was developed at The Neurosciences Institute to control a virtual reality version of the 3d center->out task.

We are moving forward on a database for both archiving and analyzing the data from daily recording sessions. We have implemented the database using PostGresQL Server, and have laid out the basic tables that will be used to archive the data. At present we are developing forms for entering data into the database from raw data files and daily log-books.

We have also run the wires in a new implantable microdrive, and are attaching connectors to the wires in preparation to implant the microdrive.

Work anticipated for the Next Reporting Period

We will be implanting the first hemisphere of monkey M early in the next reporting period. In this surgery we will be using 2 stainless-steel wire array implants that are built in-house and 2 NB electrodes.

Our data analysis will continue using fuzzy inference engines, measures of synchrony in the multiple-unit recordings, and the principle component analysis technique. We will also be

investigating a novel technique that combines fuzzy logic with neural networks to extract directional information from the cortical signal. In addition to specific effort on algorithms that reconstruct movement trajectories, we will also be seeking quantitative means to compare the merits of these disparate techniques.

Once the real-time software is debugged and stable, we will begin teaching our first animal to control the robotic arm directly. We are considering one of two approaches to this task. The first is to directly shape the animal to control the arm for movements in 3d space. The second is to use a procedure known as 'auto-shaping' to teach the animal first the significance of the robot's movements, and then to slowly teach the animal that he has direct control of the robot.